MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3 2022 / 2023 (TERM ID 2230)

ERV3036 – MACHINE VISION AND IMAGE PROCESSING

(BSc IR)

2 OCTOBER 2023
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **8** printed pages with **FOUR** questions only.
2. Answer **ALL** questions.
3. Write your answers in the Answer Booklet.

Question 1

(a) Describe the four (4) components of machine vision system.

[8 marks]

(b) Image subtraction is often used in industrial applications for detecting missing components in product assembly. Suggest a simple machine vision system to detect missing components utilizing image subtraction.

[4 marks]

(c) Sampling and quantization will convert an image from continuous form to a discrete digital form.

(i) Distinguish between sampling and quantization.

[6 marks]

(ii) Describe the effect to the digital images if we decrease the sampling rate and level of quantization.

[4 marks]

(iii) A medical image with a resolution of 1024 x 768 pixels is quantized at 4096 gray levels. What is the size of bits required to store the digitized image?

[3 marks]

Continued...

Question 2

(a) Geometrical image transformation can be represented by a 3×3 affine matrix T, given in the equation below:

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = T \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Determine the matrices T for the following transformations:

(i) Rotation by 10°

[3 marks]

(ii) Vertical shearing by a factor of $1/6$.

[3 marks]

(iii) Translation of 25 pixels down and 40 pixels to the left, followed by scaling by a factor of $1/4$ in both directions.

[3 marks]

(b) Figure Q2A shows a 7×7 image for segmentation. Using the shaded and underlined pixel as the seed pixel, apply the region growing technique on the image, based on the following parameters:

93	90	88	69	70	81	83
85	84	60	64	59	62	82
84	82	69	60	64	66	80
80	59	63	70	75	68	81
67	64	60	80	85	99	102
71	67	65	90	97	100	105
83	70	85	90	101	103	107

Figure Q2A

(i) 4-connectivity, difference between pixel values less or equal to 10.

[5 marks]

(ii) 8-connectivity, difference between pixel values less or equal to 5.

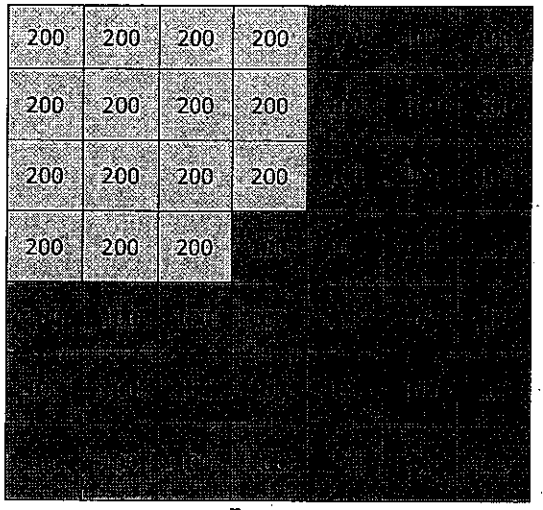
[5 marks]

Note: Redraw the image of Figure Q2A in your Answer Booklet.

Continued...

(c) Figure Q2B shows a 7×7 image, together with Prewitt edge detectors. Using the Prewitt operator masks and symmetric padding, detect the horizontal and vertical edges in the image.

[6 marks]



Image

-1	-1	-1
0	0	0
1	1	1

-1	0	1
-1	0	1
-1	0	1

Prewitt Edge Detector

Figure Q2B

Note: Redraw the image of Figure Q2B in your Answer Booklet.

Continued...

Question 3

(a) The gray level co-occurrence matrix (GLCM) $P[i,j]$ of an image is shown below.

	0	1	2	3
0	0	4	0	0
1	2	7	2	3
2	0	2	1	0
3	0	4	0	0

$P[i,j]$ $\times \frac{1}{25}$

Derive a 3-dimensional feature vector based on the entropy, energy and contrast computed from the matrix.

$$Entropy = -\sum_i \sum_j P[i,j] \log_2 P[i,j].$$

$$Energy = \sum_i \sum_j P^2[i,j].$$

$$Contrast = \sum_i \sum_j (i-j)^2 P[i,j].$$

[9 marks]

(b) Minimum distance classifier is a simple and fast classifier that classifies an object based on the distance between the object's features with each class mean vector, or centroid. But difficulties can arise when the structure of class samples is complex, such as the one shown in Figure Q3A (2-dimensional feature space for a 4-class recognition problem).

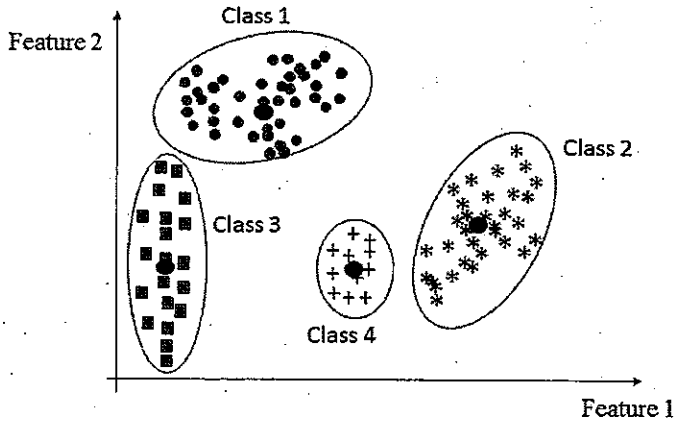


Figure Q3A

Continued...

(i) Explain the problems encountered by minimum distance classifier for the example shown in Figure Q3A.

[3 marks]

(ii) Suggest how the problems you discussed in (i) can be addressed.

[3 marks]

(c) Figure Q3B shows 3 different classes of image patterns, with 4 different samples per pattern (one pattern occupies one row of images). As a computer programmer, you are required to design and develop a program that can classify the 12 images into 3 different classes. Include your hypotheses and description of the methods that can be used for each step in the system, from pre-processing to recognition.

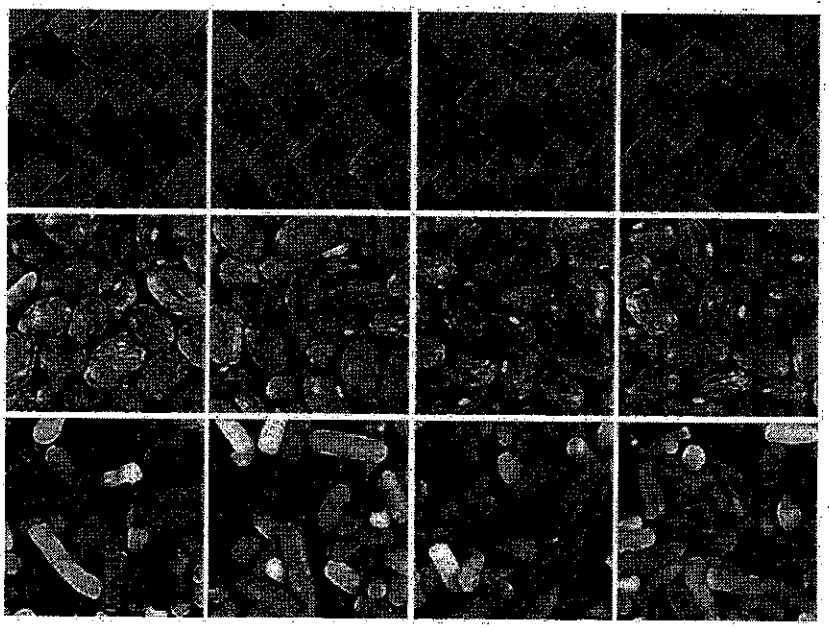


Figure Q3B

[10 marks]

Continued...

Question 4

(a) Figure Q4A shows the confusion matrix for a 9-class classification problem. The right-most column indicates the "Reject' class. Determine the following:

Predicted Object Class

True Object Class										
	45	0	0	3	0	0	2	0	0	0
	0	42	2	0	2	0	2	0	0	2
	0	2	43	0	1	0	0	3	0	1
	2	0	0	44	0	0	0	0	4	0
	0	0	1	0	47	0	0	0	0	2
	0	0	0	0	2	46	0	0	2	0
	3	2	0	0	0	0	43	0	1	1
	0	0	4	0	0	1	0	42	2	1
	1	0	0	2	0	1	0	1	45	0

Figure Q4A

(i) Overall accuracy, error rate and reject rate.

[6 marks]

(ii) Accuracy, error rate and reject rate for class α, where α is the last non-zero digit of your student ID.

[6 marks]

(b) The aim of motion estimation is to find the direction of motion for a block of pixels by comparing the reference and target frame. With the aid of a diagram, describe the hierarchical block matching algorithm used in motion compensation.

[6 marks]

(c) An interpolation of two consecutive frames in a frame rate-up conversion algorithm produced the frame in Figure Q4B.

Figure Q4B

Continued...

(i) Suggest the interpolation method that was used in the up-conversion algorithm to produce this artifact. Justify your answer.

[3 marks]

(ii) Propose a better way to perform frame up-conversion for this kind of video. Explain how your proposed method can eliminate this artifact.

[4 marks]

End of Paper